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College of Engineering & Technology
UGC Autonomous Institution
Recognized under 2(f) & 12(B) of UGC Act 1956,
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OS LAB MANUAL

II Year-I Semester

DEPARTMENT OF ARTIFICIAL INTELLIGENCE & DATA SCIENCE

ACADEMIC YEAR -2025-2026

SRI INDU COLLEGE OF ENGINEERING & TECHNOLOGY
(An Autonomous Institution under UGC, New Delhi)
Recognized under 2(f) and 12(B) of UGC Act 1956
NBA Accredited, Approved by AICTE and Permanently affiliated to JNTUH
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Department of Artificial Intelligence & Data Science

LAB MANUAL

Branch: AI&DS **Class: B.Tech- II Year-I sem**

Subject: OPERATING SYSTEMS LAB **Code: R22CSE2226**

Academic Year: 2025-26 **Regulation: R22**

Prepared By

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Head of the Department

SRI INDU COLLEGE OF ENGINEERING & TECHNOLOGY

(An Autonomous Institution under UGC, New Delhi)

B.Tech. - II Year – I Semester

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(R22CSE2226) OPERATING SYSTEMS LAB

Course Objectives:

- To provide an understanding of the design aspects of operating system concepts through simulation
- Introduce basic Unix commands, system call interface for process management, interprocess communication and I/O in Unix

Course Outcomes:

● Simulate and implement operating system concepts such as scheduling, deadlockmanagement, file management and memory management.
● Able to implement C programs using Unix system calls

List of Experiments:
1. Write C programs to simulate the following CPU Scheduling algorithms a) FCFS b) SJF c) Round Robin d) priority
2. Write programs using the I/O system calls of UNIX/LINUX operating system (open, read, write, close, fcntl, seek, stat, opendir, readdir)
3. Write a C program to simulate Bankers Algorithm for Deadlock Avoidance and Prevention.
4. Write a C program to implement the Producer – Consumer problem using semaphores using UNIX/LINUX system calls.
5. Write C programs to illustrate the following IPC mechanisms a) Pipes b) FIFOs c) Message Queues d) Shared Memory
6. Write C programs to simulate the following memory management techniques a) Paging b) Segmentation
7. Write C programs to simulate Page replacement policies a) FCFS b) LRU c) Optimal

TEXT BOOKS:

1. Operating System Principles- Abraham Silberchatz, Peter B. Galvin, Greg Gagne 7 th Edition, John Wiley

2. Advanced programming in the Unix environment, W.R.Stevens, Pearson education.

REFERENCE BOOKS:

1. Operating Systems – Internals and Design Principles, William Stallings, Fifth Edition–2005, Pearson Education/PHI

2. Operating System - A Design Approach-Crowley, TMH.

3. Modern Operating Systems, Andrew S Tanenbaum, 2nd edition, Pearson/PHI

4. UNIX Programming Environment, Kernighan and Pike, PHI/Pearson Education

5. UNIX Internals: The New Frontiers, U. Vahalia, Pearson Education

EXP1:

1. Write C programs to simulate the following CPU Scheduling algorithms

a) FCFS

1. Aim

To implement the **First Come First Serve (FCFS)** CPU scheduling algorithm in C, calculate **Waiting Time** (WT), **Turnaround Time** (TAT), and display results along with averages.

2. Theory

Definition:

FCFS is the simplest, non-preemptive scheduling algorithm where the process that arrives first is executed first.

- **Process executes in the order of arrival.**
- Once a process starts, it runs till completion.
- **Advantage:** Easy to implement
- **Disadvantage:** May cause **Convoy Effect** when long processes delay others.

Terminology

- **Burst Time (BT):** CPU time required by a process.
- **Arrival Time (AT):** Time when the process enters the ready queue.
- **Completion Time (CT):** Time when the process finishes execution.
- **Turnaround Time (TAT):**

$$TAT = CT - AT$$

- **Waiting Time (WT):**

$$WT = TAT - BT$$

3. Mathematical Model

For n processes:

1. **Waiting Time:**
   - $WT_1 = 0$
   - $WT[i] = WT[i-1] + BT[i-1]$ for $i \geq 2$
2. **Turnaround Time:**
   - $TAT[i] = WT[i] + BT[i]$
3. **Averages:**

$$AvgWT = \frac{\sum WT}{n}$$

$$AvgTAT = \frac{\sum TAT}{n}$$

4. Example Calculation

Given:

Process	BT	AT	WT	TAT
P1	5	0	0	5
P2	3	0	5	8
P3	8	0	8	16

- Avg WT = (0 + 5 + 8) / 3 = **4.33**
- Avg TAT = (5 + 8 + 16) / 3 = **9.67**

5. Algorithm

1. Input the number of processes and their **burst times**.
2. Set WT for first process = 0.
3. Calculate WT for remaining processes using cumulative BT.
4. Calculate TAT = WT + BT for each process.
5. Compute average WT and average TAT.
6. Display results.

6.C Program:

```
#include <stdio.h>
int main() { int
    n, i;
    int burst_time[20], waiting_time[20], turnaround_time[20]; int total_wt
    = 0, total_tat = 0;
    printf("Enter number of processes: "); scanf("%d",
    &n);
    printf("Enter burst time for each process:\n"); for(i =
    0; i < n; i++) {
        printf("P[%d]: ", i + 1);
        scanf("%d", &burst_time[i]);
    }
    waiting_time[0] = 0; // First process waiting time = 0

    for(i = 1; i < n; i++) {
        waiting_time[i] = waiting_time[i - 1] + burst_time[i - 1];
    }
    for(i = 0; i < n; i++) {
        turnaround_time[i] = waiting_time[i] + burst_time[i];
```

```
    total_wt += waiting_time[i];          total_tat
     += turnaround_time[i];
      }

      printf("\nProcess\tBurst Time\tWaiting Time\tTurnaround Time\n"); for(i = 0; i < n;
      i++) {
          printf("P[%d]\t%d\t\t%d\t\t%d\n", i + 1, burst_time[i], waiting_time[i],
turnaround_time[i]);
      }

      printf("\nAverage Waiting Time = %.2f\n", (float)total_wt / n); printf("Average
      Turnaround Time = %.2f\n", (float)total_tat / n);
      return 0;
}
```

7.Output:

```
Enter number of processes: 3 Enter
burst time for each process: P[1]: 5
P[2]: 3
P[3]: 8
```

Process	Burst Time	Waiting Time	Turnaround Time
P[1]	5	0	5
P[2]	3	5	8
P[3]	8	8	16

Average Waiting Time = 4.33 Average

Turnaround Time = 9.67

8.Execution Flow:

| P1 | -----5-----| P2 | -----3-----| P3 | ----------8----------|

0 58 16

9.Conclusion:

- FCFS executes processes in arrival order.
- It is simple but can cause delays if a large process arrives first (Convoy Effect).
- Best suited for batch processing systems.

1.Write C programs to simulate the following CPU Scheduling algorithms

B) SJF

C Program

```
#include <stdio.h>


int main() {
    int n, i, j, pos, temp;
    int burst_time[20], process[20], waiting_time[20], turnaround_time[20]; int total_wt =
    0, total_tat = 0;


    printf("Enter number of processes: "); scanf("%d",
    &n);


    printf("Enter burst time for each process:\n"); for(i =
    0; i < n; i++) {
        printf("P[%d]: ", i + 1);
        scanf("%d", &burst_time[i]);
        process[i] = i + 1; // Store process numbers
    }
```

```
// Sort burst times with process number using selection sort
 for(i = 0; i < n; i++) {
    pos = i;
    for(j = i+1; j < n; j++) { if(burst_time[j] <
        burst_time[pos])
            pos = j;
    }
    temp = burst_time[i]; burst_time[i] =
    burst_time[pos]; burst_time[pos] =
    temp;

    temp = process[i]; process[i]
    = process[pos]; process[pos]
    = temp;
}

// First process has 0 waiting time waiting_time[0] =
0;

// Calculate waiting time for(i =
1; i < n; i++) {
    waiting_time[i] = 0; for(j
    = 0; j < i; j++)
        waiting_time[i] += burst_time[j]; total_wt +=
    waiting_time[i];
}
```

```
    // Calculate turnaround time for(i =
    0; i < n; i++) {
        turnaround_time[i] = burst_time[i] + waiting_time[i]; total_tat +=
        turnaround_time[i];
    }

    printf("\nProcess\tBurst Time\tWaiting Time\tTurnaround Time\n"); for(i = 0; i < n;
    i++)
        printf("P[%d]\t%d\t\t%d\t\t%d\n", process[i], burst_time[i],
waiting_time[i], turnaround_time[i]);

    printf("\nAverage Waiting Time = %.2f", (float)total_wt / n); printf("\nAverage
    Turnaround Time = %.2f\n", (float)total_tat / n);

    return 0;
}
```

7. Sample Output

```
text
Enter number of processes: 4
Enter burst time for each process:
P[2]: 6
P[3]: 8
P[4]: 7
P[5]: 3

Process Burst Time Waiting Time Turnaround Time
P[5]    3          0            3
P[2]    6          3            9
P[4]    7          9            16
P[3]    8          16           24

Average Waiting Time = 7.00
Average Turnaround Time = 13.00
```

1.Write C programs to simulate the following CPU Scheduling algorithms

C)Round Robin

```
#include <stdio.h>
int main() { int
    n;
    printf("Enter Total Number of Processes: ");
    scanf("%d", &n);
    int wait_time = 0, ta_time = 0;
    int arr_time[n], burst_time[n], temp_burst_time[n]; int x = n;
    // number of remaining processes
    for (int i = 0; i < n; i++) {
        printf("Enter Details of Process %d\n", i + 1); printf("Arrival Time:
        ");
        scanf("%d", &arr_time[i]);
        printf("Burst Time: ");
        scanf("%d", &burst_time[i]);
        temp_burst_time[i] = burst_time[i];
    }
    int time_slot;
    printf("Enter Time Slot: ");
    scanf("%d", &time_slot);
```

```
    int total = 0, counter = 0, i = 0;
    printf("\nProcess ID  Burst Time  Turnaround Time  Waiting Time\n");

    while (x != 0) {
        if (temp_burst_time[i] <= time_slot && temp_burst_time[i] > 0) { total +=
            temp_burst_time[i];
            temp_burst_time[i] = 0;
            counter = 1;
        } else if (temp_burst_time[i] > 0) {
            temp_burst_time[i] -= time_slot; total
            += time_slot;
        }

        if (temp_burst_time[i] == 0 && counter == 1) { x--;
            printf("P%-9d %-11d %-15d %-10d\n",
                    i + 1, burst_time[i], total - arr_time[i], total - arr_time[i] -
burst_time[i]);
            wait_time += total - arr_time[i] - burst_time[i]; ta_time
            += total - arr_time[i];
            counter = 0;
        }
        if (i == n - 1) { i
            = 0;
        } else if (arr_time[i + 1] <= total) {
```

```
            i++;
        } else {
            i = 0;
        }
    }

    float average_wait_time = (float)wait_time / n; float
    average_turnaround_time = (float)ta_time / n;

    printf("\nAverage Waiting Time: %.2f", average_wait_time); printf("\nAverage
    Turnaround Time: %.2f\n", average_turnaround_time);

    return 0;
}
```

Output:

```
Enter Total Number of Processes: 3
Enter Details of Process 1
Arrival Time: 0
Burst Time: 5
Enter Details of Process 2
Arrival Time: 1
Burst Time: 4
Enter Details of Process 3
Arrival Time: 2
Burst Time: 2
Enter Time Slot: 2

Process ID  Burst Time  Turnaround Time  Waiting Time
P3          2           4                2
P2          4           9                5
P1          5           11               6

Average Waiting Time: 4.33
Average Turnaround Time: 8.00

--------------------------------
Process exited after 92.2 seconds with return value 0
Press any key to continue . . .
```

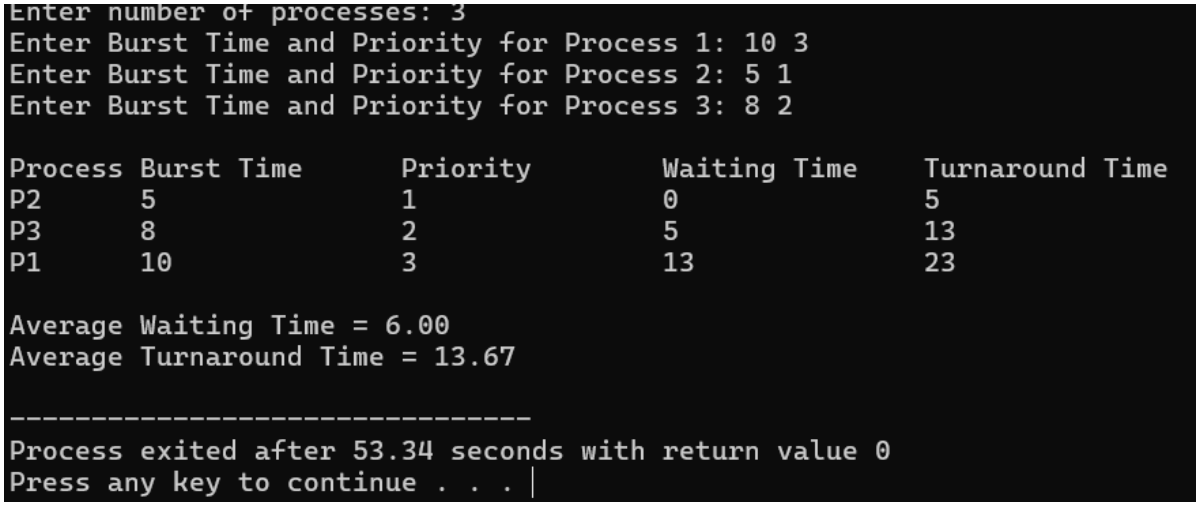
1.Write C programs to simulate the following CPU Scheduling algorithms
D)Priority

```
#include <stdio.h>

  int main() {

      int n, i, j, pos, temp;

      int burst_time[20], p[20], wait_time[20], tat[20], priority[20]; float

      total_wait = 0, total_tat = 0;


printf("Enter number of processes: "); scanf("%d", &n);

      for(i = 0; i < n; i++) {

          printf("Enter Burst Time and Priority for Process %d: ", i + 1); scanf("%d %d",

          &burst_time[i], &priority[i]);

          p[i] = i + 1;  // process ID

      }
      // Sort processes by priority (lower number = higher priority) for(i = 0; i

      < n; i++) {

          pos = i;

          for(j = i + 1; j < n; j++) { if(priority[j] <

              priority[pos])

                  pos = j;

          }

          // Swap priority
```

```
    temp = priority[i]; priority[i]
    = priority[pos]; priority[pos]
    = temp;

    // Swap burst time temp
    = burst_time[i];
    burst_time[i] = burst_time[pos]; burst_time[pos] =
    temp;
    // Swap process ID temp
    = p[i];
    p[i] = p[pos];
    p[pos] = temp;
}

// Calculate waiting times
wait_time[0] = 0;
for(i = 1; i < n; i++) {
    wait_time[i] = 0; for(j =
    0; j < i; j++)
        wait_time[i] += burst_time[j];
    total_wait += wait_time[i];
}

// Calculate turnaround time and print table
printf("\nProcess\tBurst Time\tPriority\tWaiting Time\tTurnaround Time\n");
```

```
    for(i = 0; i < n; i++) {
        tat[i] = burst_time[i] + wait_time[i]; total_tat +=
        tat[i];
        printf("P%d\t%d\t\t%d\t\t%d\t\t%d\n", p[i], burst_time[i], priority[i], wait_time[i],
tat[i]);
    }

    printf("\nAverage Waiting Time = %.2f", total_wait / n);
    printf("\nAverage Turnaround Time = %.2f\n", total_tat / n);

    return 0;
}
```

Output:



2.Write programs using the I/O system calls of UNIX/LINUX operating system (open, read, write, close, fcntl, seek, stat, opendir, readdir)

Aim: To perform I/O system calls of UNIX/LINUX operating system (open, read, write, close, fcntl, seek, stat, opendir, readdir)

/* Open GDB Online Debugger to Perform below Linux calls.--> Login First if required then perform all actions*/

/* 1.create a sample text file on pc desktop with name test.txt—usually notepad file and write some content called

Hello GDB Online Debugger.How are you.I am your friend */

/* Upload that file into GDB Online Debugger and execute the below program*/

/* On left side pane□Click □Create New Project□Write the prog□Execute*/

Program:

1. open(), read(), write(), close()

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>

int main() {
 int fd;
    char buffer[100];

    // Open file in read-only mode
    fd = open("test.txt", O_RDONLY);

    if (fd < 0) {
```

```
        perror("open"); return
        1;
    }

    // Read contents
    int n = read(fd, buffer, sizeof(buffer));

    if (n < 0) {
        perror("read");
        return 1;
    }
    buffer[n] = '\0';

    // Write contents to STDOUT write(1,
    buffer, n);

    // Close file
    close(fd);
     return 0;
}
```

Output:

2. fcntl() – File control

Program:

```
#include <stdio.h>

#include <fcntl.h> #

include <unistd.h>


int main() {
    int fd = open("test.txt", O_RDONLY);

    if (fd < 0) {
        perror("open");
        return 1;
    }


    // Get file descriptor flags
    int flags = fcntl(fd, F_GETFL);
    printf("File access mode: %d\n", flags & O_ACCMODE);


    close(fd);
     return 0;
}
```

Output:

3. lseek() – File offset positioning

```
#include <stdio.h>
#include <fcntl.h>
#include <unistd.h>

int main() {
    int fd = open("test.txt", O_RDONLY);
    char buffer[20];

    // Move file pointer 5 bytes ahead
    lseek(fd, 5, SEEK_SET);

    // Read after seeking
    int n = read(fd, buffer, 15);
    buffer[n] = '\0';
    printf("Data after seek: %s\n", buffer);

    close(fd);
    return 0;
    }
```

O/P:

4. stat() – File information

```
#include <stdio.h>
#include <sys/stat.h>

int main() {
    struct stat fileStat;

    if (stat("test.txt", &fileStat) < 0) {
        perror("stat");
        return 1;
    }

    printf("File Size: %ld bytes\n", fileStat.st_size);
    printf("Number of Links: %ld\n", fileStat.st_nlink);
    printf("File Permissions: %o\n", fileStat.st_mode & 0777);
    return 0;
}
```

O/P:

5.opendir(), readdir() – Directory operations

```
#include <stdio.h>
#include <dirent.h>

int main() {
    DIR *dir;
    struct dirent *entry;

    dir = opendir(".");
    if (dir == NULL) {
        perror("opendir");
        return 1;
    }

    printf("Files in current directory:\n");
    while ((entry = readdir(dir)) != NULL) {
        printf("%s\n", entry->d_name);
    }

    closedir(dir);
    return 0;
}
```

O/P:

3. Write a C program to simulate Bankers Algorithm for Deadlock Avoidance and Prevention.

This program checks whether the system is in a **safe state** using **Banker's Algorithm**.

C Program

```
#include <stdio.h>

int main() {
    int n, m, i, j, k;

    printf("Enter number of processes: ");
    scanf("%d", &n);

    printf("Enter number of resources: ");
    scanf("%d", &m);

    int alloc[n][m], max[n][m], need[n][m];
    int avail[m];

    printf("\nEnter Allocation Matrix:\n");
    for(i = 0; i < n; i++) {
        for(j = 0; j < m; j++) {
            scanf("%d", &alloc[i][j]);
        }
    }
    printf("\nEnter Maximum Matrix:\n");
    for(i = 0; i < n; i++) {
        for(j = 0; j < m; j++) {
            scanf("%d", &max[i][j]);
        }
    }

    printf("\nEnter Available Resources:\n");
    for(i = 0; i < m; i++) {
        scanf("%d", &avail[i]);
    }
```

```
// Calculate Need Matrix
  for(i = 0; i < n; i++) {
    for(j = 0; j < m; j++) {
      need[i][j] = max[i][j] - alloc[i][j];
    }
  }

  int finish[n], safeSeq[n];
  for(i = 0; i < n; i++)
    finish[i] = 0;

  int count = 0;

  while(count < n) {
    int found = 0;

    for(i = 0; i < n; i++) {
      if(finish[i] == 0) {

        // Check if all resources can be allocated
        for(j = 0; j < m; j++) {
          if(need[i][j] > avail[j])
            break;
        }

        if(j == m) {
          // Process can execute
          for(k = 0; k < m; k++) {
            avail[k] += alloc[i][k];
          }
          safeSeq[count++] = i;
          finish[i] = 1;
          found = 1;
        }
      }
    }
    // No process could be executed
    if(found == 0) {
      printf("\nSystem is NOT in safe state (Deadlock may occur)\n");
      return 0;
    }
  }
```

```
 // Safe sequence
    printf("\nSystem is in SAFE state.\nSafe Sequence:\n");

    for(i = 0; i < n; i++) {
        printf("P%d", safeSeq[i]);

        if(i != n - 1)
            printf(" -> ");
    }

    printf("\n");

    return 0;
}
```

Input:
Enter number of processes: 5
Enter number of resources: 3

Enter Allocation Matrix:
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2

Enter Maximum Matrix:
7 5 3
3 2 2
9 0 2
2 2 2
4 3 3

Enter Available Resources:
3 3 2

Output:

```
System is in SAFE state.

Safe Sequence:
P1 -> P3 -> P4 -> P0 -> P2
```

4. Write a C program to implement the Producer – Consumer problem using semaphores using UNIX/LINUX system calls.

This program uses:

- **POSIX Threads (`pthread`)**
- **Semaphores (`sem_t`)**
- UNIX/Linux synchronization system calls.

C Program:

```
#include <stdio.h>
#include <stdlib.h>
#include <pthread.h>
#include <semaphore.h>
#include <unistd.h>

#define BUFFER_SIZE 5

int buffer[BUFFER_SIZE];
int in = 0;
int out = 0;

// Semaphores
sem_t empty;
sem_t full;
pthread_mutex_t mutex;

// Producer Function
void *producer(void *arg) {
   int item;

   for(int i = 1; i <= 10; i++) {

      item = rand() % 100;

      sem_wait(&empty);              // wait if buffer full
      pthread_mutex_lock(&mutex);    // enter critical section

      buffer[in] = item;
      printf("Producer produced: %d\n", item);

      in = (in + 1) % BUFFER_SIZE;
```

```
  pthread_mutex_unlock(&mutex);  // leave critical section
        sem_post(&full);              // increase full count

        sleep(1);
    }

    pthread_exit(NULL);
}

// Consumer Function
void *consumer(void *arg) {
    int item;

    for(int i = 1; i <= 10; i++) {

        sem_wait(&full);              // wait if buffer empty
        pthread_mutex_lock(&mutex);    // enter critical section

        item = buffer[out];
        printf("Consumer consumed: %d\n", item);

        out = (out + 1) % BUFFER_SIZE;

        pthread_mutex_unlock(&mutex);  // leave critical section
        sem_post(&empty);             // increase empty count

        sleep(2);
    }

    pthread_exit(NULL);
}

int main() {

    pthread_t p_thread, c_thread;

    // Initialize semaphores
    sem_init(&empty, 0, BUFFER_SIZE);
    sem_init(&full, 0, 0);
```

```
 // Initialize mutex
    pthread_mutex_init(&mutex, NULL);

    // Create producer and consumer threads
    pthread_create(&p_thread, NULL, producer, NULL);
    pthread_create(&c_thread, NULL, consumer, NULL);

    // Wait for threads to finish
    pthread_join(p_thread, NULL);
    pthread_join(c_thread, NULL);

    // Destroy semaphores and mutex
    sem_destroy(&empty);
    sem_destroy(&full);
    pthread_mutex_destroy(&mutex);

    return 0;
}
```

O/P:

```
Producer produced: 83
Consumer consumed: 83

Producer produced: 25
Producer produced: 67
Consumer consumed: 25

Producer produced: 91
Consumer consumed: 67

Producer produced: 12
Consumer consumed: 91

Producer produced: 48
Consumer consumed: 12
...
```

5.Write C programs to illustrate the following IPC mechanisms a) Pipes b) FIFOs c) Message Queues d) Shared Memory

(a) PIPE Program

```
#include <stdio.h>
#include <unistd.h>
#include <string.h>

int main() {

    int fd[2];
    char write_msg[] = "Hello through Pipe";
    char read_msg[50];

    pipe(fd);

    if(fork() == 0) {
        // Child Process
        close(fd[1]); // close write end
        read(fd[0], read_msg, sizeof(read_msg));
        printf("Child received: %s\n", read_msg);
    }
    else {
        // Parent Process
        close(fd[0]); // close read end
        write(fd[1], write_msg, strlen(write_msg)+1);
    }

    return 0;
}
```

O/P:

Child received: Hello through Pipe

(b) FIFO (Named Pipe)

```
#include <stdio.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <unistd.h>
#include <string.h>

int main() {

    char *fifo = "myfifo";
    mkfifo(fifo, 0666);

    int fd;
    char arr1[] = "Hello FIFO";
    char arr2[100];

    if(fork() == 0) {
        // Child reads
        fd = open(fifo, O_RDONLY);
        read(fd, arr2, sizeof(arr2));
        printf("Received: %s\n", arr2);
        close(fd);
    }
    else {
        // Parent writes
        fd = open(fifo, O_WRONLY);
        write(fd, arr1, strlen(arr1)+1);
        close(fd);
    }

    return 0;
}
```

O/P:

Received: Hello FIFO

(c) Message Queue

```
#include <stdio.h>
#include <sys/ipc.h>
#include <sys/msg.h>
#include <string.h>

struct msg_buffer {
    long msg_type;
    char msg_text[100];
} message;

int main() {

    key_t key;
    int msgid;

    key = ftok("progfile", 65);

    msgid = msgget(key, 0666 | IPC_CREAT);

    message.msg_type = 1;

    printf("Enter message: ");
    fgets(message.msg_text, sizeof(message.msg_text), stdin);

    msgsnd(msgid, &message, sizeof(message), 0);

    printf("Message sent.\n");

    msgrcv(msgid, &message, sizeof(message), 1, 0);

    printf("Message received: %s\n", message.msg_text);

    msgctl(msgid, IPC_RMID, NULL);

    return 0;
}
```

O/P:
Enter message: Hello IPC
Message sent.
Message received: Hello IPC

(d) Shared Memory

```
#include <stdio.h>
#include <sys/ipc.h>
#include <sys/shm.h>
#include <string.h>

int main() {

    key_t key = 1234;

    int shmid = shmget(key, 1024, 0666 | IPC_CREAT);

    char *str = (char*) shmat(shmid, NULL, 0);

    printf("Write Data: ");
    gets(str);

    printf("Data written in memory: %s\n", str);

    shmdt(str);

    shmctl(shmid, IPC_RMID, NULL);

    return 0;
}
```

O/P:

Write Data: Operating System
Data written in memory: Operating System

Compilation Commands (Linux)

Pipe / FIFO

```
gcc pipe.c -o pipe
./pipe
```

Message Queue

```
gcc msgqueue.c -o msg
./msg
```

Shared Memory

```
gcc shm.c -o shm
./shm
```

6. Write C programs to simulate the following memory management techniques a) Paging b) Segmentation

a) C Program for Paging Technique

```
#include <stdio.h>

int main() {
    int pages, frames, page_size;
    int logical_address;
    int page_number, offset;

    printf("Enter page size: ");
    scanf("%d", &page_size);

    printf("Enter logical address: ");
    scanf("%d", &logical_address);

    // Calculate page number and offset
    page_number = logical_address / page_size;
    offset = logical_address % page_size;

    printf("\nPage Number = %d\n", page_number);
    printf("Offset = %d\n", offset);

    return 0;
}
```

O/P:

```
Enter page size: 100
Enter logical address: 245

Page Number = 2
Offset = 45
```

b) C Program for Segmentation Technique

```
#include <stdio.h>

int main() {
    int segment, offset;
    int base[5], limit[5];
    int physical_address;

    printf("Enter base and limit for 5 segments:\n");

    for(int i = 0; i < 5; i++) {
        printf("Segment %d Base: ", i);
        scanf("%d", &base[i]);

        printf("Segment %d Limit: ", i);
        scanf("%d", &limit[i]);
    }

    printf("\nEnter segment number: ");
    scanf("%d", &segment);

    printf("Enter offset: ");
    scanf("%d", &offset);

    // Check offset validity
    if(offset < limit[segment]) {
        physical_address = base[segment] + offset;

        printf("\nPhysical Address = %d\n", physical_address);
    }
    else {
        printf("\nSegmentation Fault! Offset exceeds limit.\n");
    }

    return 0;
}
```

O/P:

```
Enter base and limit for 5 segments:

Segment 0 Base: 1000
Segment 0 Limit: 500

Segment 1 Base: 2000
Segment 1 Limit: 300

Segment 2 Base: 3000
Segment 2 Limit: 400

Segment 3 Base: 4000
Segment 3 Limit: 600
```

Segment 4 Base: 5000
Segment 4 Limit: 700

Enter segment number: 2
Enter offset: 120

Physical Address = 3120

7.Write C programs to simulate Page replacement policies a) FCFS b) LRU c) Optimal

a) FCFS / FIFO Page Replacement Program

```
#include <stdio.h>

int main() {
   int pages[50], frames[10];
   int n, f, i, j, fault = 0, index = 0, found;

   printf("Enter number of pages: ");
   scanf("%d", &n);

   printf("Enter page reference string:\n");
   for(i = 0; i < n; i++)
      scanf("%d", &pages[i]);

   printf("Enter number of frames: ");
   scanf("%d", &f);

   for(i = 0; i < f; i++)
      frames[i] = -1;

   for(i = 0; i < n; i++) {

      found = 0;

      for(j = 0; j < f; j++) {
         if(frames[j] == pages[i]) {
            found = 1;
            break;
         }
      }

      if(found == 0) {
         frames[index] = pages[i];
         index = (index + 1) % f;
         fault++;
      }

      printf("\nFrames: ");
      for(j = 0; j < f; j++)
         printf("%d ", frames[j]);
   }

   printf("\n\nTotal Page Faults = %d\n", fault);

   return 0;
}
```

O/P:
Enter number of pages: 8
Enter page reference string:
1 2 3 4 1 2 5 1
Enter number of frames: 3

Frames: 1 -1 -1
Frames: 1 2 -1
Frames: 1 2 3
Frames: 4 2 3
Frames: 4 1 3
Frames: 4 1 2
Frames: 5 1 2
Frames: 5 1 2

Total Page Faults = 7

b) LRU Page Replacement Program

```
#include <stdio.h>

int main() {

   int pages[50], frames[10], time[10];
   int n, f, i, j, pos, fault = 0, count = 0;
   int found;

   printf("Enter number of pages: ");
   scanf("%d", &n);

   printf("Enter page reference string:\n");
   for(i = 0; i < n; i++)
      scanf("%d", &pages[i]);

   printf("Enter number of frames: ");
   scanf("%d", &f);

   for(i = 0; i < f; i++)
      frames[i] = -1;

   for(i = 0; i < n; i++) {

      found = 0;

      for(j = 0; j < f; j++) {
         if(frames[j] == pages[i]) {
            count++;
            time[j] = count;
            found = 1;
            break;
         }
      }

      if(found == 0) {

         pos = 0;

         for(j = 1; j < f; j++) {
            if(time[j] < time[pos])
               pos = j;
         }

         frames[pos] = pages[i];
         count++;
         time[pos] = count;
         fault++;
      }
```

```
printf("\nFrames: ");

for(j = 0; j < f; j++)
        printf("%d ", frames[j]);
    }

    printf("\n\nTotal Page Faults = %d\n", fault);

    return 0;
}
```

O/P:

```
Enter number of pages: 8
Enter page reference string:
1 2 3 4 1 2 5 1
Enter number of frames: 3

Frames: 1 -1 -1
Frames: 1 2 -1
Frames: 1 2 3
Frames: 4 2 3
Frames: 4 1 3
Frames: 4 1 2
Frames: 5 1 2
Frames: 5 1 2

Total Page Faults = 7
```

c) Optimal Page Replacement Program

```
#include <stdio.h>

int main() {

    int pages[50], frames[10];
    int n, f, i, j, k, fault = 0, found;

    printf("Enter number of pages: ");
    scanf("%d", &n);

    printf("Enter page reference string:\n");
    for(i = 0; i < n; i++)
        scanf("%d", &pages[i]);

    printf("Enter number of frames: ");
    scanf("%d", &f);

    for(i = 0; i < f; i++)
        frames[i] = -1;

    for(i = 0; i < n; i++) {

        found = 0;

        for(j = 0; j < f; j++) {
            if(frames[j] == pages[i]) {
                found = 1;
                break;
            }
        }

        if(found == 0) {

            int pos = -1, farthest = i + 1;

            for(j = 0; j < f; j++) {

                int found_future = 0;

                for(k = i + 1; k < n; k++) {
                    if(frames[j] == pages[k]) {
                        if(k > farthest) {
                            farthest = k;
                            pos = j;
                        }
                        found_future = 1;
                        break;
                    }
                }
```

```
    if(!found_future) {
                pos = j;
                break;
            }
        }

        if(pos == -1)
            pos = 0;

        frames[pos] = pages[i];
        fault++;
    }

    printf("\nFrames: ");
    for(j = 0; j < f; j++)
        printf("%d ", frames[j]);
    }

    printf("\n\nTotal Page Faults = %d\n", fault);

    return 0;
}
```

O/P:

```
Enter number of pages: 8
Enter page reference string:
1 2 3 4 1 2 5 1
Enter number of frames: 3

Frames: 1 -1 -1
Frames: 1 2 -1
Frames: 1 2 3
Frames: 1 2 4
Frames: 1 2 4
Frames: 1 2 4
Frames: 1 2 5
Frames: 1 2 5

Total Page Faults=5
```